June 26, 1945. R. L. HOOD 2,379,233

PHOTOELECTRIC CONTROLLING OR RECORDING APPARATUS

Filed Oct. 16, 1944 2 Sheets-Sheet 1

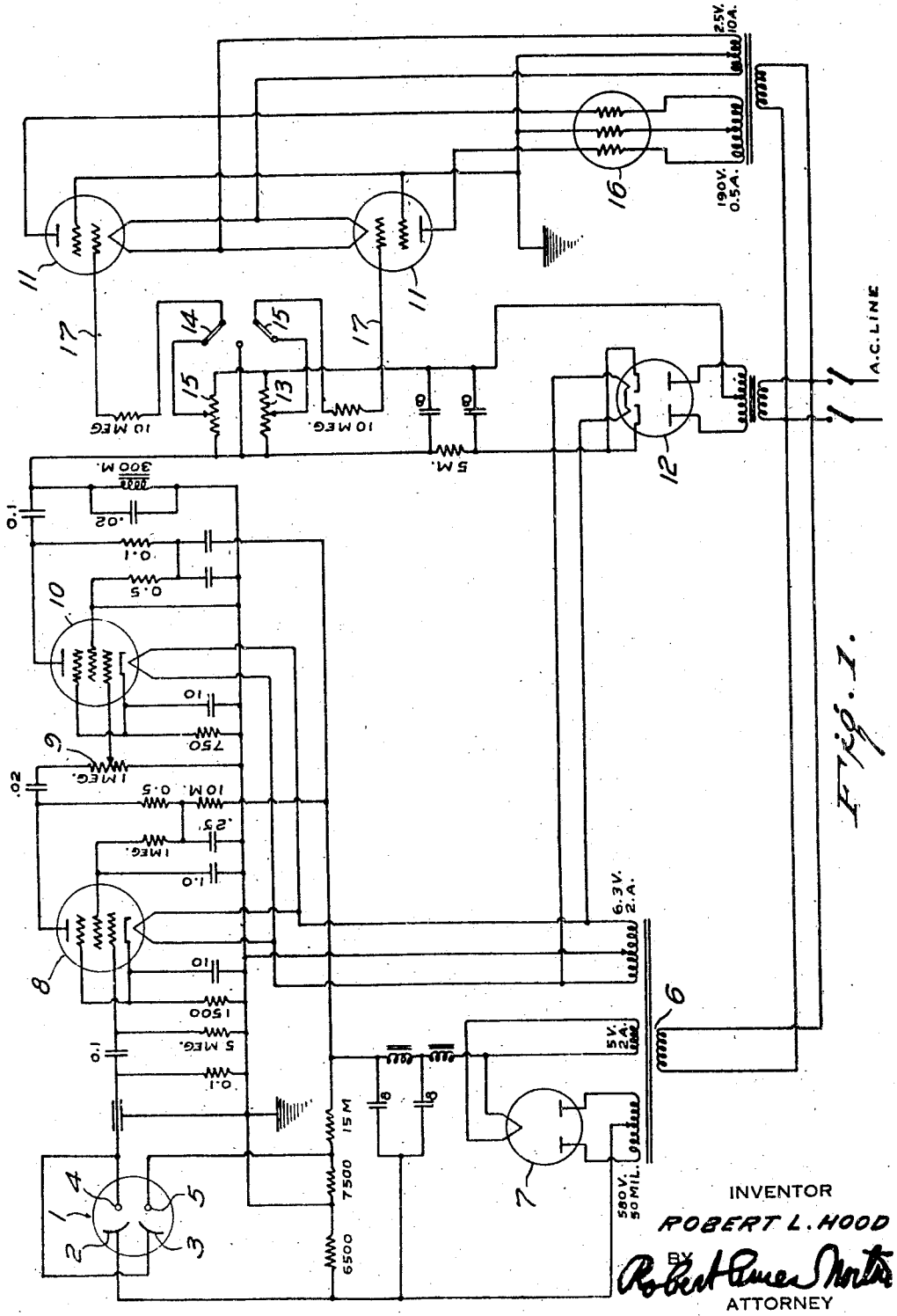


Fig. 1.

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PHOTOELECTRIC CONTROLLING OR RECORDING APPARATUS

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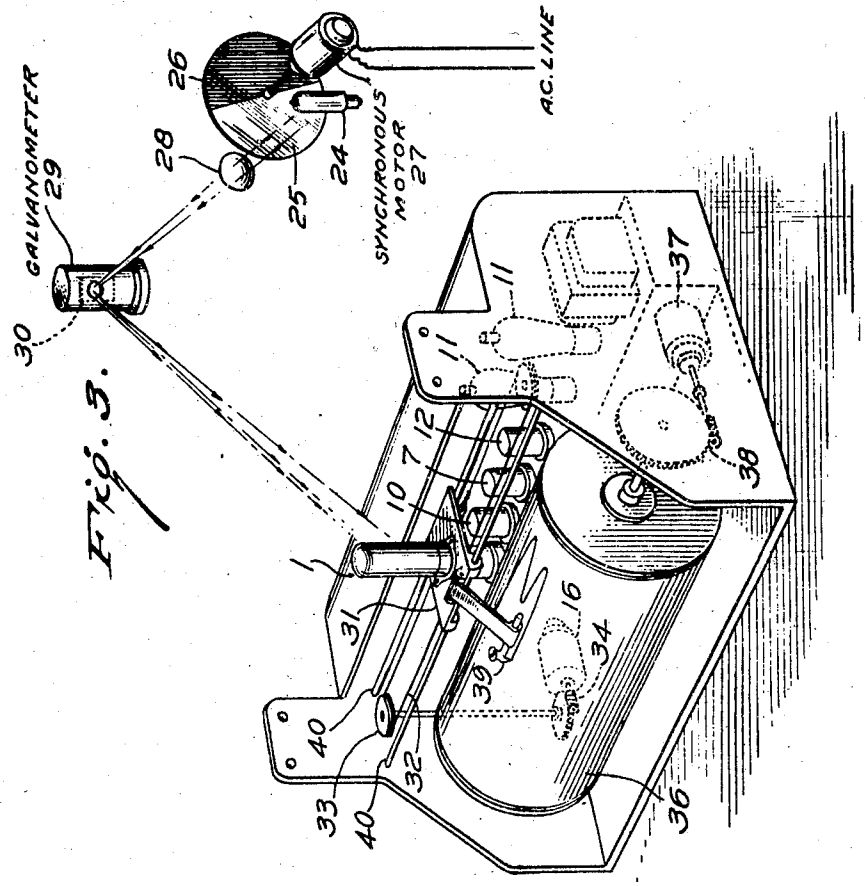


Fig. 3.

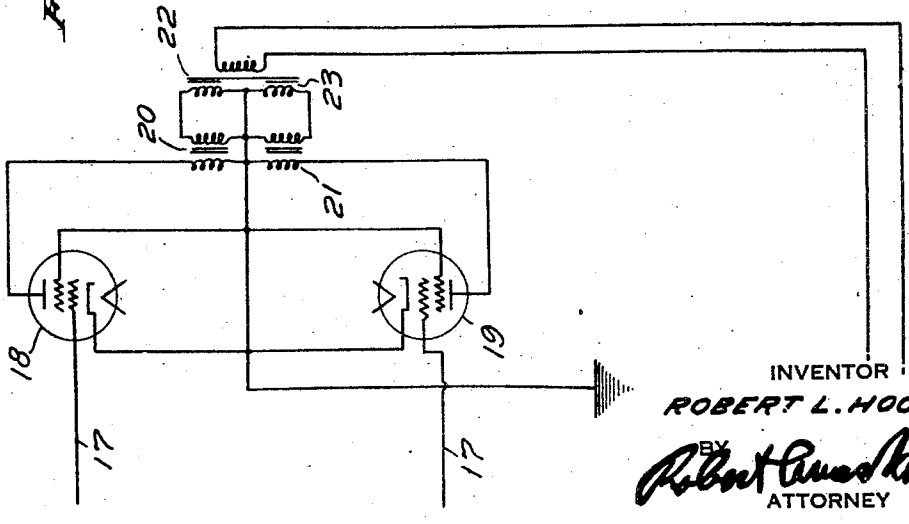


Fig. 2.

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PHOTOELECTRIC CONTROLLING OR RECORDING SYSTEM

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6 Claims. (Cl. 234—1.5)

This invention relates to an improved photoelectric control system for balancing or recording, and particularly to improvements in the electrical circuit thereof.

Many instruments require the recording or following of a moving light beam. Typical of this type of problem is a recorder for a mirror galvanometer. The invention will be described in connection with a recorder or a mirror galvanometer, it being understood that the inventive novelty is not limited to following the movements of a light beam from this type of instrument.

In the past it has been proposed to mount a twin cathode phototube on a movable carriage and to connect the carriage to a motor driven by the output of an amplifier, the input of which is fed from the twin cathode tube. Operation of the motor is in a direction to move the twin cathode tube so that it will eventually come to rest with the beam of light striking between the cathodes or illuminating them equally. A recorder of the type described greatly enhances the utility of a mirror galvanometer or any other device in which a light beam is deflected. However, operation of the device hitherto proposed has left much to be desired from the standpoint of power, and particularly reliability of operation. The device used a direct current amplifier with two Thyratrons, the control grids of which were connected respectively to the cathodes of the twin phototube. Amplification, and hence power output, was low, reducing the sensitivity of the instrument, and it was also subject to all of the difficulties of a direct current amplifier which tends to drift with changes in supply voltages and other conditions which are not part of the input signal from the twin cathode phototube. An even more serious drawback lies in the fact that diffused light from the room in which the device is operating will affect the cathodes and will be interpreted as a direct current signal. It is necessary, therefore, to operate in a room with low illumination and extreme care has to be exercised to prevent any stray light from striking the phototube.

The present invention avoids all of the difficulties of the known instrument by causing the light beam to flicker at a suitable frequency and using an efficient alternating current amplifier which permits developing adequate power free from any spurious results due to drift with changes in supply voltages and other electrical disturbances not connected with the input signal.

It is also possible to operate in a brightly lighted room, and even when the recorder is illuminated with intense sunlight no inaccuracy results because the amplifier responds only to alternating current signal and is unaffected by any steady stray light. Another advantage is that it is not necessary to use a beam so narrow that in its normal position it will not strike either cathode. For the purpose of the present invention the beam may be fairly wide, as it does not make any difference if it illuminates both cathodes in the centered position so long as the illumination of both cathodes is the same. This imposes less rigid conditions on the beam and permits less critical operation. It is particularly advantageous when the recorder is built as a separate unit which can be used with various mirror galvanometers. Lining up of the two instruments is simplified and slight misalignment does not interfere with operation.

Preferably the amplifier is self-powered and contains no batteries which present a maintenance problem. In spite of the greatly increased sensitivity of the device stable operation is obtained without the use of batteries, and instruments embodying the present invention have such high sensitivity that they can be used for many purposes for which the proposed device is not suitable.

Essentially the novelty of the present invention lies in the use of flickering light and in the type of amplifier. The features of the invention can be used in a wide variety of devices which require the following of a light beam without materially altering the constituent parts of such devices. This general applicability of the amplifier and phototube of the present invention constitutes an important practical advantage, as it can readily be added to existing devices without major reconstruction.

In the electrical circuits illustrated in the drawings resistors are expressed in ohms, unless otherwise noted. Megohms are abbreviated Meg. and the customary symbol M is used for 1,000 ohms. Condensers are rated in microfarads and volts and amperes carry the customary abbreviations.

The invention will be described in connection with the drawings, in which:

Fig. 1 is a diagrammatic representation of the electric circuit used in the present invention;

Fig. 2 is a diagram of a modified output circuit; and

Fig. 3 is a perspective view of a mirror galvanometer and recorder embodying the features of the present invention.

The electric circuit usable in the present inven-

tion is shown in Fig. 1. A twin cathode phototube 1 is movably mounted and encounters a movable flickering beam of light. One of the cathodes 2 is connected to the negative center tap of the high voltage winding of transformer 6 which, with the full wave rectifier tube 7, constitutes a power supply. The other cathode 3 is connected to the anode 4 opposite the first cathode, which is in turn connected to a shielded lead and condenser to the control grid of input tube 8 of a high gain resistance coupled audio frequency amplifier. The other anode 5 is connected to a point on the voltage divider of the power supply at a point where the potential above ground is of substantially the same value as the negative potential with respect to ground on cathode 2.

The signal impressed on the tube 8 represents the differential between the illumination of the two cathodes 2 and 3 and is an audio frequency signal at flicker frequency of the light beam, the phase depending on which cathode is the more strongly illuminated. The output of tube 8 is fed to the tube 10, amplification being controlled by the potentiometer 9.

The output from tube 10 is capacitively coupled to a push-pull output stage employing two Thyratrons 11. The grids of the tubes are given a fixed bias by an independent power supply using a full wave rectifier 12. The bias on each tube is balanced by two 100,000 ohm potentiometers 13, each grid being fed through a high resistance and wire 17, and the potentiometers being provided with short circuiting switches 14 and 15 respectively. The output of the tetrodes operates an electric motor 16, the direction of rotation of which depends on the phase of the signal on the grid of tube 8.

Fig. 2 illustrates a modified output circuit in which the wires 17 lead to the grids of Thyratrons 18 and 19. The plates of these tubes are connected to ground through the windings 20 and 21 of transformers, the other windings of which are in series with the shading coils 22 and 23 of a shaded pole motor. During one cycle of signalling one Thyratron ignites and during the other part of the cycle the second Thyratron ignites. The Thyratrons when actuated serve to short circuit the shading coils with the result that the motor rotates in a direction determined by the phase of the input signal to the amplifier.

Tubes 8 and 10 of the amplifier are connected in a rather conventional resistance coupled circuit. This portion of the circuit may be replaced with equivalent audio frequency amplifier circuits of known characteristics. The resistance coupled amplifier shown has operated satisfactorily in practice and is shown as typical.

Fig. 3 shows a perspective of the present invention applied to a recorder for a mirror galvanometer. The conventional source of light is shown at 24 and is caused to flicker at audio frequency by the rotation of a disc provided with a transparent semi-circle 25 and an opaque semi-circle 26. Rotation of the disc is by a suitable motor 27 which may advantageously be a synchronous motor. The flickering beam is then collimated by the lens 28 and strikes the mirror 30 of the mirror galvanometer 29. The reflected beam strikes the twin cathode phototube 1 which is mounted on a movable frame 31 capable of horizontal movement along the guide rods 40. Three wires lead from the phototube through a shielded flexible cable to an amplifier (not shown) having a circuit such as is shown in Figs. 1 and 2. The output of the amplifier causes the motor 16 to turn which drives a cable 32 connected to the framework 31 through worm gears 34 and pulley 33. Movement of the framework 31 is in a direction to cause the reflected light beam from the galvanometer to be centered between the cathodes. Any deflection of the beam illuminates one cathode more than the other and causes the motor 16 to turn until the framework 31 has been moved to a position where the cathodes are equally illuminated. A hinged pen 39 is mounted in the framework 31 and moves over the surface of a drum 36 which is turned by a motor 37 through the worm gears 38. The rotation of the drum may be in accordance with time or any other quantity which is to be used as a coordinate in the final curve. Suitable coordinate paper is mounted on the drum in the conventional manner and the pen 39 dropped into place. The pen will then trace a curve corresponding to the galvanometer deflections.

Sometimes the light beam may miss the phototube altogether, as when there has been a sudden excessive deflection of the galvanometer or when the machine is first started. The switches 14 and 15 (Fig. 1) may then be used to move the frame 31 with the phototube manually until the beam strikes the cathodes, at which time automatic operation sets in.

A flicker beam from a mirror galvanometer is shown in Fig. 3 as the source of light which the phototube has to follow. As has been stated above this is an important but by no means the only type of instrument in which the present invention is useful. The phototube of the present invention is of course not concerned with the source of the flickering light beam and will follow any flickering light beam of proper frequency, regardless of how this beam was produced and deflected. Similarly, the particular method of flickering is not material to the operation of the device. An extremely simple form of mechanical flickering is shown. The invention is not in any sense limited to producing a flickering beam by this means. Any other of the well-known flickering devices may be used, the exact construction of the flickering device forming no part of the present invention.

The preferred modifications of the present invention have been illustrated in connection with their use in a recording instrument. The invention is not limited thereto as the motion of the carriage on which the twin cathode phototube is mounted may be employed to actuate any desired device. For example, it may actuate control devices through continuous potentiometers or relays at predetermined deflections of the flickering light beam. The design of such control devices is conventional as their structure is in no way altered by the operation of the beam follower of the present invention.

I claim:

1. A light beam following or a recording device comprising in combination means for producing a flickering light beam capable of deflection in a single plane, the deflections of which are to be followed or recorded, a twin cathode phototube mounted in a carriage capable of movement in said plane transverse to the axis of the flickering beam, a flicker frequency alternating current vacuum tube amplifier, a circuit connecting said phototube to the input of the amplifier capable of impressing alternating current signals of different phase onto the input of said amplifier when the cathodes are unequally illuminated with flickering light, at least one power supply for said amplifier capable of

rectifying alternating current to supply all direct current voltages in said amplifier, an electric motor actuated by the output of said amplifier, the direction of the rotation of the motor being determined by the phase of the input signal to the amplifier, drive means connecting said motor with the carriage and capable of moving said carriage in a direction to eliminate unequal illumination of the cathodes of the photocell by the flickering beam.

2. A light beam following or a recording device compriisng in combination means for producing a flickering light beam capable of deflection in a single plane, the deflections of which are to be followed or recorded, a twin cathode phototube mounted in a carriage capable of movement in said piane transverse to the axis of the flickering beam, a flicker frequency alternating current vacuum tube amplifier, a circuit connecting said phototube to the input of the amplifier capable of impressing alternating current signals of different phase onto the input of said amplifier when the cathodes are unequally illuminated with flickering light, at least one power supply for said amplifier capable of rectifying alternating current to supply all direct current voltages in said amplifier, an electric motor actuated by the output of said amplifier, the direction of the rotation of the motor being determined by the phase of the input signal to the amplifier, drive means connecting said motor with the carriage and capable of moving said carriage in a direction to eliminate unequal illumination of the cathodes of the photocell by the flickering beam, and manual switching means adapted to cause the motor to turn in either direction when the switching means is manually actuated.

3. A recorder according to claim 1 in which the carriage carries a disengageable recording means movable over a moving recording surface.

4. A recorder according to claim 2 in which the carriage carries a disengageable recording means movable over a moving recording surface.

5. A recording mirror galvanometer according to claim 1 in which the beam of flickering light is reflected from the mirror of a mirror galvanometer and the carriage carries a disengageable recording means movable over a moving recording surface.

6. A recording mirror galvanometer according to claim 2 in which the beam of flickering light is reflected from the mirror of a mirror galvanometer and the carriage carries a disengageable recording means movable over a moving recording surface.

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